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LEAKS FROM HIGH PRESSURE FIRE SERVICE MAINS[1]

By Henry B. Machen

For many years water works officials have discussed leakage from distribution systems and the effect of changes in pressure without being able to come to definite conclusions, due to the fact that, except that for single supply lines laid generally under most favorable conditions, after the main has been placed in service it has been impossible to separate leakage from consumption.

The high pressure fire system in the Borough of Manhattan, New York City, due to the fact that New York has not permitted any private connection to its fire mains, gives an opportunity to make tests on a distribution system of 128 miles of mains, 2728 hydrants and over 4748 valves covering an area of 3675 acres. The system has received during its ten years' life most trying tests. Each year it has had the pressure raised from say 35 pounds to from 125 to 250 pounds, an average of over two thousand times a year, due to fire alarms within the district, and for each period of twelve hours in duration during which no fire alarm has sounded the pressure has been raised for one-half hour to 200 pounds for testing out. It is hard to believe that any other water system in the world has gone through similar service conditions.

Table 1 gives in considerable detail the castings used, separated by contracts, by size of main and further sub-divided into full lengths of pipe of each size, offsets and bends of varying degree of curvature combined, 3-ways and 4-ways and short pieces. The short pieces were in many cases manufactured in the short lengths at the foundry; in other cases, they were cut from full lengths of pipe in the field. All castings used in the work except the pieces cut in the field were tested to 600 pounds at the foundry.

The 3-ways and the 4-ways were steel castings and considerable trouble was experienced at certain of the steel foundries in obtaining satisfactory castings. Two of the foundries, however, had practically no trouble in furnishing castings up to the specifications, the troubles of the others being due to lack of experience in this class of work.

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[1] Read before the Richmond Convention, May 10, 1917.

TABLE 1

Pipe and specials in the Manhattan high pressure fire system

ITEMS	TOTALS ALL CONTRACTS	PER CENT
8 inch full lengths	437	3.2
8 inch bends and offsets	3,257	24.1
8 inch 3-ways and 4-ways	297	2.2
8 inch short pieces	9,533	70.5
Total	13,524	100.0
12 inch full lengths	26,729	64.8
12 inch bends and offsets	4,937	12.0
12 inch 3-ways, 4-ways	2,045	4.9
12 inch short pieces	7,563	18.3
Total	41,274	100.0
16 inch full lengths	9,561	64.8
16 inch bends and offsets	1,515	10.3
16 inch 3-ways, 4-ways	894	6.0
16 inch short pieces	2,783	18.9
Total	14,753	100.0
20 inch full lengths	3,894	62.3
20 inch bends and offsets	703	11.3
20 inch 3-ways, 4-ways	417	6.7
20 inch short pieces	1,233	19.7
Total	6,247	100.0
24 inch full lengths	3,513	65.1
24 inch bends and offsets	422	7.8
24 inch 3-ways, 4-ways	626	11.6
24 inch short pieces	838	15.5
Total	5,399	100.0
All sizes:		
Full lengths	44,134	54.4
Bends and offsets	10,834	13.3
3-ways, 4-ways	4,279	5.3
Short pieces	21,950	27.0
Total	81,197	100.0

The mains were all laid in the lower portion of Manhattan Island, where subsurface conditions are most congested. This subsurface congestion shows readily in the figures given in the table by the large number of bends and short pieces of pipe used, even after the city had availed itself of its right to order moved gas mains and other interfering subsurface structures.

After the mains were laid they were subjected to an acceptance test of 450 pounds for a period of ten minutes for the earlier contracts and for twenty minutes for the later ones, the leakage being measured and for acceptance had to come within the limit of 4 gallons per linear foot of pipe joint per twenty-four hours. The results of these tests are shown in table 2, which gives, separated into the same contracts, the linear feet of pipe laid of each size, the total linear feet of pipe joint, the allowable leakage, based on the specifications of 4 gallons per linear foot of joint per twenty-four hours, the actual leakage for the test period and reduced to the twenty-four hour basis.

TABLE 2

Lengths of pipe and leakage in the Manhattan high pressure fire system

ITEMS	CONTRACTS 6-7-8-9	CONTRACTS 19-20-21-22-23-27-28-29-30	TOTAL ALL CONTRACTS
24 inch pipe laid, linear feet	35,662.0	13,656.6	49,318.6
20 inch pipe laid, linear feet	29,849.8	26,330.0	56,179.8
16 inch pipe laid, linear feet	47,177.2	87,673.4	134,850.6
12 inch pipe laid, linear feet	154,466.1	224,429.0*	*378,895.1
8 inch pipe laid, linear feet	26,213.9	28,760.6	54,974.5
6 inch pipe laid, linear feet	860.0		860.0
Total pipe laid, linear feet	294,229.0	380,849.6	675,078.6
Linear feet of pipe joint	122,438	160,545	282,983
Allowable leakage for 24 hours	489,850	642,139	1,131,989
Actual leakage for 10 minutes	2,138.8		2,138.8
Actual leakage for 20 minutes		4,762.4	4,762.4
Actual leakage for 24 hours	307,741.	343,391	651,132
Total number of tests	647	720	1,367
Date put in service	July 1908 to November 1909	July 1910 to December 1914	July 1908 to December 1914

* Includes 150 feet of wrought iron pipe.

In testing, the test sections were in all cases between valves and doubtless a portion of the loss was due to water passing the valves limiting the section under test.

From the total column of table 2 it will be seen that the mains were limited in the acceptance test of 450 pounds per square inch to a leakage at the rate of about 800 gallons per minute for the entire 128 miles. The actual gross leakage of all the tests was 452 gallons per minute. Today there is a leakage, as shown on the Venturi meters, of 950 gallons per minute at an average pressure of 33 pounds, or nearly double the amount of leakage at 450 pounds pressure at the tests from ten to four years ago.

Investigations have been made to locate the leaks, but due to lack of force the work has not been systematically carried on. However, due to the wide range in pressures, property owners have themselves reported eight connections which had been placed evidently by mistake. There may be others not placed by mistake in which advantage is taken of the higher pressures available at times to fill tanks. The occasional erratic movement of the pen in the Venturi chart may be an indication of this.

The author had until recently a very firm belief that the leakage was past the main valve of the hydrants and was carried off to the sewer through the drain pipe connecting the drip and sewer. This belief has been shattered by an aquaphone test of each hydrant made by a most careful and competent inspector who covered every one of the 2728 hydrants and found but 51 (1.9 per cent) on which any sound could be detected indicating leakage which could not be stopped by tightening the valves.

Of course, it might be said that a certain number of hydrants might be not tightly closed at all times in such a large number, but the system of maintenance is such that each hydrant is examined and repaired if necessary immediately after going out of service at a fire by an experienced machinist who reports to a follow-up system that the hydrant has been examined by him and left in good condition. The firemen, after an alarm, are the only users of the hydrants. Should any one else open a hydrant it is immediately known by an alarm bell operated by the Venturi meter recorder on the priming line.

During the past six years many miles of streets have been opened for the construction of the rapid transit subways, exposing over 54,000 linear feet of the high-pressure mains. No leakage has been found in the joints except an occasional sweat and from this evidence the Bureau of Water Supply is inclined to believe that the loss of water is not at the joints.

Fig. 1 gives the result of a test under varying pressure made on December 8, 1916. Attention is called to the almost straight line of the upper portion of the curve, which seems to indicate that the leakage is not from fixed openings, from which a leakage varying as the square of the pressure should be expected.

It may be that the symmetrical results obtained and shown on the curve are but accidental; that as the pressure increased the main valves of the hydrants, which close under pressure, closed more tightly, reducing the leakage in the hydrant; that at the same time stuffing boxes in valves which are tight under low pressure might leak under the higher; that cracks in the pipe or steel casting not open under low pressure open under the higher.

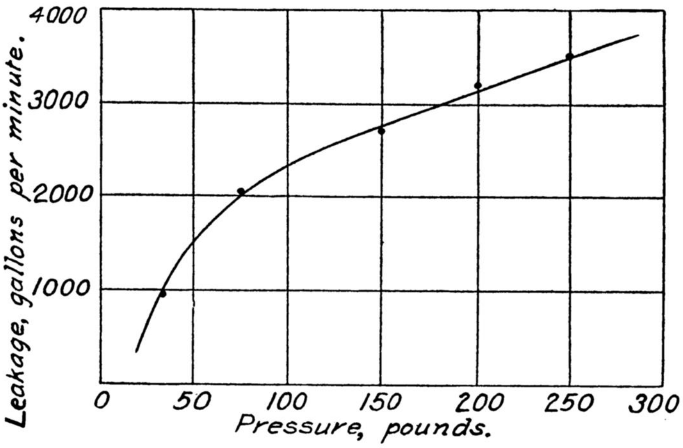

Fig 1.

Owing to a report of water coming in through the walls of a large sewer, there was located a split pipe which reduced the leakage under 35 pounds pressure by over 100 gallons a minute. This leak may have been of long duration, as at the time of starting excavations no indication existed at the street surface.

The author presents the above facts for the purpose of discussion and not as showing any definite conclusion as to leakage.